NAAPO (North American AstroPhysical Observatory)

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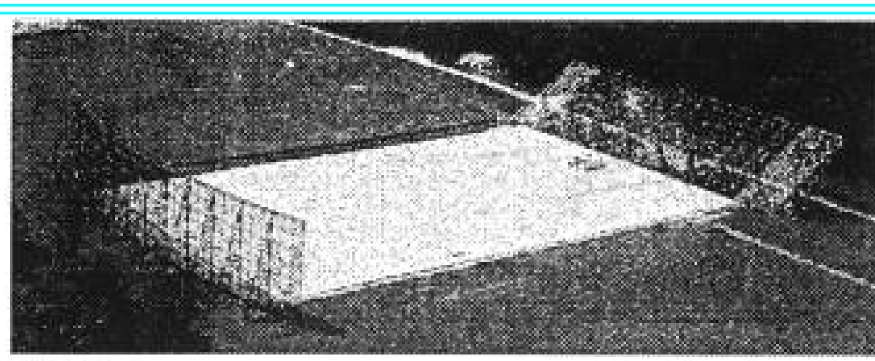
SIGNALS



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SILICON VALLEY PIONEER, BERNARD OLIVER, IS DEAD AT 79

Bernard M. (*Barney*) Oliver, who directed research at the *Hewlett-Packard Corporation* for four decades, died of heart failure at his Los Altos Hills home on Thursday. He was 79.

Trained as an electrical engineer, Dr. Oliver was pivotal in the flowering of modern technology in the Silicon Valley. It was under his leadership that the first hand-held calculators were produced at Hewlett-Packard in the early 1970's. Later in his career, he founded Biosys, a company specializing in biological controls for agriculture, and turned his attentions to the search for extraterrestrial intelligence, or **SETI**.

Upon completing his studies at Stanford and the Califomia lnsftute of Technology, where he received his doctorate in 1940, Dr. Oliver joined the Bell Telephone Laboratories in New York. He initially worked on schemes for improving the quality of then new television systems, but shifted his attentions to radar after America became involved in the Second World War. His enthusiasm for this work caused him initially to reject an invitation by fellow Stanford alumni William Hewlett and David Packard to join their growing electronics company in Palo Alto. But a year later, in 1952, Dr. Oliver became Hewlett-Packard's Director of Research. In 1957, he was named a Vice President, and joined the Board of Directors.

Dr. Oliver held over fifty patents and was the architect of much of the groundbreaking technical development at Hewlett-Packard. He is probably best known for his work on the HP-35, the first hand-held calculator. The possibility of such a device occurred as Hewlett-Packard engineers were considering what product should follow the successful HP 9100A, a programmable desktop electronic calculator which used discrete components. In 1970 integrated circuits, which combined many such components in one package, were just becoming available. "We realized that if we took the 9100 and converted it to integrated circuits, we could miniaturize it and carry it in our shirt pockets, said Oliver. Hewlett liked the idea, and gave Oliver's group a year to develop the product. Today, its successors are used by millions of people, and Dr. Oliver received the 1986 National Medal of Science for this work. He also served as a Vice President and later as President of the Institute of Electrical and Electronic Engineers (*IEEE*).

At the same time he was developing miniaturized calculators, Dr. Oliver co-directed a summer study at NASA's Ames Research Center on a scheme to use radio telescopes to search for evidence of advanced extraterrestrial societies. This study, called **Project Cyclops**, became the basis for much of the modern **SETI** effort. Prominent among these was an ambitious NASA program for which Dr. Oliver served as a senior manager. In 1993, when congressional action ended NASA involvement in **SETI**, Dr. Oliver was instrumental in finding philanthropic funding to continue part of the experiment under the auspices of the non-profit **SETI Institute** in Mountain View, where he was also a Board member. At the time of his death, he was working as a Senior Scientist for **Project Phoenix**, as the privatized search is called. Dr. Oliver grew up on the family ranch in Soquel Valley, and graduated from Stanford University in 1935 prior to his graduate work in electrical engineering and physics at Caltech. In 1945 he married Priscilla (*Suki*) Newton, who died in December, 1994. In addition to his contributions to technology, Dr. Oliver served on the Palo Alto School Board and was a supporter of the Los Altos Repertory Company, where his wife often performed.

He is survived by his three children, Karen Newton Oliver of Vancouver, B.C., Gretchen More Oliver of San Francisco, and William Eric Oliver also of San Francisco.

A memorial service will be held at 2:00 pm on Friday, December 1, at the First United Methodist Church, 625 Hamilton Avenue, Palo Alto. The family has requested that in lieu of flowers, donations be sent to the **SETI Institute**, 2035 Landings Drive, Mountain View, CA 94043.

COORDINATOR'S CORNER
By: Phil Barnhart

The *Ohio State Lantern* reported this week that E. Gordon Gee overspent his discretuionary fund by $68,000 this past year. This is no great news, it seems to happen quite regularly in large bureacracies. My observation is that this amount would keep **Big Ear** operating comfortably for about 4 years!

Important as a university president's discretionary funds are for *P. R.* and fund-raising, why must the priorities of a research/educational institution not be adequately addressed when university wide publicity and low budget reseach is considered. The university policy seems to be biased against the radio observatory *BECAUSE* it has delved in the past into supposedly controversial areas.

I have decided to take a cruise to unravel my nerves. I will report on the event upon my return at Christmas time.

HERB JOHNSON'S REPORT

There has been a bit of discussion about possible "missions" for **Argus**; and also a bit of discussion about meteors and radio. There may be some additional overlap in these domains, namely the subject of **N**ear **E**arth **O**bjects, or *NEO*'s.

There has been growing interest in these objects, mostly because more people are looking for them, and there has been some speculation and even study of the probability of "too-close" encounters between Earth and a good-sized asteroid in the near future.

Recently, as I understand it, a pitch for funds for a more directed optical sky survey (*Skywatch I think?, or Spacewarn?*) was turned down. It is likely a smaller but more distributed search will be done by individuals and amateur groups. (*Sound familiar?*).

I'm not sure if **Argus** can contribute to this project. One can imagine that the operation of some "planetary radar", otherwise used for mapping of asteroids and planets, might also be picked up by an **Argus** array and the scattering from asteroids re-integrated into some locations. I think it would be a non-trivial task. However, it may be of the same order of task as beam synthesis, with the advantage of knowing the frequency, bandwidth, pulsewidth, and timing of the original transmission! So it may conceivably provide a "testing" capacity, at least for returns from known objects (*the Moon, planets, etc.*)

I can't contribute much more than these observations, except that the signal loss from lunar reflections of radio is about 240dB(!), to give you some sense of scale and range. Probably some brief e-mail to the folks who do planetary radar could provide more details. If misery loves company, maybe we can share resources with the NEO folks!

WOW! SIGNAL Q&A
By: Jerry Ehman

Paul Shuch, of **The SETI League**, asked Bob Dixon four questions (*listed below*) regarding the feed horns at the time of the "**Wow!**" source detection and Bob has asked me to respond. I have e-mailed Paul a near duplicate of this e-mail message. Since these questions and the answers are very important, I decided to send them out to those persons on the **OSURO** listserver as a part of documenting important info.

Paul's questions were:

Q1: Where the computer printout indicates RA, may I assume that's where the NULL between the two feedhom patterns is pointed? If so, and if I understand this correctly, then RA 19:17:24 (*where the Wow! peaked*) was really in a NULL, with one horn pointed east, the other west of that RA. Is this correct?

Al: NO! The printed RA was supposed to be the RA of the peak of the positive horn at the end of the 10-second integration interval. Unfortunately, I made a mistake in the sampling/analysis program (*called N50CH*) by adding a negative horn squint at a certain point in the program when I should have subtracted that negative horn squint. This error was not found until after the "Wow!" source was detected. [*See Answer to Q2 below for more info.*] The NULL between the two horns is not a nicely defined point and so was never used in any of our calculations. In fact, at declinations well away from the equator, there was a plateau of low intensity values between the negative values occurring from the negative (*west*) horn and the positive values occurring from the positive (*east*) horn. Remember that the output from the Dicke-switched receiver (*switching between the two horns at 79 Hz*) was the integrated difference between the two horns (*in the sense positive-horn output minus negative-horn output*). Thus, a source in only the positive horn generates a positive output while a source in only the negative horn generates a negative output.

Q2: What was the spacing between the phase centers of the two horns, in either angular or temporal measurements?

A2: The computer printout for "**Wow!**" shows a calculated epoch 1950.0 right ascension (*RA*) at the END of the 10-second integration period (*ten values of intensity/channel [1/second] were averaged together to obtain the intensity*). Note that there was typically 12 seconds between successive data points; 2 extra seconds during which no data was collected were needed to do real-time analysis. Since the intensity for the 10-second integration period is an average over that interval, it is more appropriate to assign the RA at the MIDDLE ofthe interval as the most representative RA. Thus, all else being correct, subtract 5 seconds from the printed RA.

The sampling/analysis program (*N50CH*) used a horn squint of -138 seconds of time. This value should have been subtracted from the sidereal time to convert to observed RA but, until some time after the "**Wow!**" source detection, it was added. The value of -138 seconds (= *2 minutes 18 seconds*) represented the best estimate at the time of first writing the program of the offset of the POSITIVE (*EAST*) horn at the equator (*declination = 0*). The program did account for the 1/cos(declination) effect previously mentioned. Thus, the error of adding rather than subtracting means that 309.9 seconds of time should be added to the RA correct for this error. Note that the RA values on the printout represent the RA for the POSITIVE horn. The separation between the two horns was never a parameter in N50CH because no calculations or printout of negative-horn RAs was made.

To answer the question regarding the separation between the two horns, I will state three different results.

<u>Method 1:</u> Using some data on the 11.53 jansky source OY372 given to me by Russ Childers, I fit a Gaussian to each of the main beam responses and computed the difference between the positions of the peaks; the result converted to the equator was 150.7 seconds of time in the sense that the negative (*west*) horn has a squint of 150.7 seconds more negative than the -138 seconds of the positive (*east*) horn. In other words, the squint of the positive horn would be -138 + (-150.7) = -238.7 (= *approx. -239 seconds*).

<u>Method 2:</u> In a 1980 report by Debbie Cree, a grad student doing a study on the

antenna for John Kraus, she measured the offsets from the focus as: 4.10 feet for the positive (*east*) horn and 8.79 feet for the negative (*west*) horn. Note that both horns were located west of the focus (*i.e., both horns were offset to the same side*); the east (*positive*) horn was simply less west than the west (*negative*) horn. Taking the focal length of the paraboloid as 420 feet, the horn squints converted to the equator were: -140.57 seconds for the positive horn; -301.33 seconds for the negative horn; and a difference of -160.76 seconds.

Method 3: John Kraus, in an internal document dated 1/30/94 entitled "*The Tantalizing 'Wow!' Signal*" quotes RA (*1950.0*) of the source as either 19h 22m 22s +/-5s or 19h 25m 12s +/-5s. The smaller RA would be for the case that the source was observed in the horn closer to the focus, namely the positive (*east*) horn, and the larger RA would represent the source being observed in the negative (*west*) horn. The difference between these two values is -2m 50s (= *-170s*). Converting to the equator, this gives a difference in the squint of -151.4 seconds. I haven't seen his calculations so I don't know what data he used.

The values of the three methods are: -150.7, -160.8 and -151.4 seconds of time at the equator. The average of these three values is -154.3 seconds of time and the standard deviation is 4.6 seconds. That is the best value I have at this time and is my answer to Q2.

There is a related question to ask. That is: What are the best estimates of the 1950.0 RA for each of the two horns? I will now attempt to answer that question.

Another factor to consider in estimating the two possible values of the 1950.0 RA is the accuracy of the clock we used. During the 1963-1973 **Ohio Sky Survey**, the **EECO** clock (*keeping sidereal time*) could be kept to within +/- 0.5 second. Due to old age, it eventually became less reliable. By the time of the **SETI** observing program, we would occasionally notice that the clock was off by 1 or 2 seconds and we had no ability to predict when it got off or how. Thus, an uncertainty of RA of +/-2s just due to the clock should be assumed.

Now let me compute the two possible RAs (*one if the source came in the positive horn and the other if it came in the negative horn*). Subtracting 5s to associate RAs with the center of the integration period and using the average between the -138s and the -140.57s positive horn squints (*viz. -139.285s*), and using the average of the two models fit to the **Wow!** source, I obtain the smaller RA to be: 19h 17m 19.74s -5s -2*

(-139.285s/cos(-27.05)) = 19h 22m 27.5s. Similarly, I obtain the larger RA to be: 19h 22m 27.5s - (-154.3/cos(-27.05)) = 19h 25m 20.8s. Note that John Kraus's smaller RA is 5.5s less than mine, while his larger RA is 8.8s less than mine.

Finally, what is the estimated uncertainty for each computed RA? Combining a clock error of 2s with a standard deviation of the difference of squint of 4.6 seconds plus a little more to be conservative, I would estimate that the standard error for each position should be stated as +/- 7s.

Q3: You identified the half-power beamwidth for me as 8 arcmin in azimuth, 40 arcmin in elevation. Is that with respect to a SINGLE feedhorn?

A3: YES. At the observing frequency of 1415 MHz, the main beam pattern of each horn at the half-power level was (*is*) essentially elliptical on the sky with a width (*HPBW = half-power beamwidth*) of about 8 arcminutes in right ascension (*or azimuth*) by about 40 arcminutes in declination (*or elevation*). Remember that the HPBW in each coordinate gets smaller as one increases the frequency. The two horns are virtually identical so that the main beams are also virtually identical; in fact they correlate with a correlation coefficient of approximately 0.9993 = 99.93%. There are small differences between corresponding sidelobes for the first 2 or 3 that are visible on either side of the main beam. However, the "**Wow!**" source was not strong enough to show any sidelobes.

Q4: I calculated (*from the above*) a half-power time of 32 seconds. Plotting the actual signal, it looks like half-power for the Wow! was more like 37 seconds. Any idea what I'm doing wrong?

A4: You need to account for the cosine of the declination effect in the conversion between angle and time. 1 arcminute = 4 seconds of time only on the equator. In general: 1 arcminute = (4/cosine(declination)) seconds of time. Thus, at a declination of -27.05 degrees (= *-27 degrees 03 minutes*), 1 arcminute = 4.49 seconds of time, and thus the 8 arcminute HPBW in RA would equal 35.93 seconds of time. I have tried fitting both Gaussian and (sin(x)/x)^2 models to the "**Wow!**" data and have obtained HPBWs of 38.62 seconds and 40.15 seconds, respectively (*at the observed declination, not corrected to the equator*). Both the signal-to-noise of the data and the model affect the computed HPBWs.

OSU RADIO OBSERVATORY IS OHIO GUINNESS ENTRY

ed. note: *The following is a letter written by our own Dr. Dixon to the Columbus Dispatch, regarding the Radio Observatory's entry in the 1996 Guinness Book of World Records. The Dispatch published an article regarding entries in the book from Ohio, and managed to omit the Big Ear in their article.*

OSU RADIO OBSERVATORY IS OHIO GUINNESS ENTRY

The Nov. 9 "*Dispatch*" has a review by "*Dispatch*" reporter Jim Massie about the 1996 "*Guinness Book of Records.*" He mentions several Ohio entries.

Unfortunately, he overlooked the largest Ohio entry of all, which takes up more space than all the other Ohio entries combined. It is represented in a two-thirds of a page article with two photographs.

I refer to the article on page 82 of "*Guinness*" about the Ohio State University Radio Observatory, which searches for extraterrestrial intelligence and is right here in central Ohio.

Dr. Robert S. Dixon, director of **SETI** program
Ohio State University Radio Observatory, Columbus
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COSMIC RAY MYSTERY MAY BE SOLVED
By: Ron Baalke

Physicists from Japan and the United States have discovered a possible solution to the puzzle of the origin of high energy cosmic rays that bombard Earth from all directions in space.

Using data from the Japanese/U.S. X-ray astronomical satellite ASCA, physicists have found what they term "the first strong observational evidence" for the production of these particles in the shock wave of a supernova remnant, the expanding fireball produced by the explosion of a star.

"*We are very pleased to contribute to the solution of an 83 year old mystery,*" said **Dr. Koyama**, of the *Department of Physics at Kyoto University*, Kyoto, Japan.

Cosmic rays were discovered in 1912 by the Austrian physicist Victor Hess, who subsequently received the Nobel Prize in Physics for that work. They are subatomic particles, mostly electrons and protons, that travel near the speed of light. Ever since their discovery, scientists have debated where cosmic rays come from and how ordinary subatomic particles can be accelerated to such high speeds. Supernova remnants have long been thought to provide the high energy cosmic rays, but the evidence has been lacking until now.

The international team of investigators used the satellite to determine that cosmic rays are generated at a high rate in the remains of the Supernova of 1006 AD — which appeared to medieval viewers to be as bright as the Moon — and that they are accelerated to high velocities by a process first suggested by the nuclear physicist Enrico Fermi in 1949.

The satellite contains telescopes for simultaneously taking images and spectra of X-rays from celestial sources, allowing astronomers to distinguish different types of X-ray emission from nearby regions of the same object.

The tell-tale clue to the discovery was the detection of two oppositely-located regions in the rapidly expanding supernova remnant, the debris from the stellar explosion. The two regions glow intensely in what is called synchrotron radiation, which is produced when electrons move at nearly the speed of light through a magnetic field in space. The remainder of the supernova remnant, in contrast, produces ordinary "thermal" X-ray emission, meaning radiation from hot gases such as oxygen, neon, and gaseous forms of magnesium, silicon, sulfur, and iron.

The cosmic rays are accelerated in the two regions that glow with synchrotron radiation, the physicists concluded. Specifically, charged particles are accelerated to nearly the speed of light and energies of 100 trillion electron volts as they bounce off turbulent regions inside the shock front from the supernova explosion. This amount of energy is over 50 times higher than can be produced in the most powerful particle accelerator on Earth. Like a ping pong ball bouncing between a table and a paddle while the paddle is brought ever closer to the table, an electron, proton or an atomic nucleus bounces back and forth within the supernova remnant, continually gaining speed, until it attains a high energy. This process was first proposed as a theory by Fermi in 1949.

"*Since we found cosmic ray acceleration under way in the remnant of Supernova*

1006, this process probably occurs in other young supernova remnants," according to **Dr. Robert Petre**, of *NASA's Goddard Space Flight Center's Laboratory for High Energy Astrophysics*, Greenbelt, MD. Astronomers estimate that there is a supernova explosion in the Milky Way galaxy, which contains the Earth, about once every 30 years. Supernova 1006 is classified by astronomers as the explosion of a white dwarf star, known as a Type IA supernova. Other types of supernovae, involving the collapse of massive stars in the Milky Way, and in galaxies beyond, may also produce cosmic rays.

The discovery observations were made with solid-state X-ray cameras on the ASCA satellite, which was launched from Kagoshima Space Center, Japan, aboard a Japanese M-3S-II rocket on Feb. 20, 1993. Major contributions to the scientific instrumentation were provided by Goddard's Laboratory for High Energy Astrophysics and by the Center for Space Research at the Massachusetts Institute of Technology.

"*The capability to obtain spatially resolved X-ray spectra — that is to determine the different spectra at various locations in an image — is a tremendous advance in space technology,*" said **Dr. Stephen Holt**, *Director of Space Sciences at Goddard.*

Approximately 25 cosmic rays bombard one square inch every second in space just outside the Earth's atmosphere. The atmosphere shields the surface of the Earth from these "primary" cosmic rays. However, collisions of the primary cosmic rays with atoms in the upper atmosphere produce slower moving "secondary" cosmic rays, some of which reach ground level and even may penetrate to depths of many feet below the ground.

TOPEX/POSEIDON MISSION STATUS
November 1, 1995

PUBLIC INFORMATION OFFICE
JET PROPULSION LABORATORY
CALIFORNIA INSTITUTE OF TECHNOLOGY
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
PASADENA, CALIF. 91109
TELEPHONE (818) 354-5011

The satellite and sensors continue to operate as expected, and ground system computers are performing well. The satellite tape recorders have been played back, and the daily science and engineering data products are being produced.

The satellite has completed more than 15,000 orbits of the Earth since its launch in 1992. TOPEX/Poseidon is now in its 115th 10-day data collection cycle.

VOYAGER MISSION STATUS
November 1, 1995

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PASADENA, CALIF. 91109
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Voyager 1 is currently 9.15 billion kilometers (*5.69 billion miles*) from Earth, having traveled 10.87 billion kilometers (*6.75 billion miles*) since its launch in September 1977. The Voyager 1 spacecraft is departing the solar system at a speed of 17.46 kilometers per second (*39,055 miles per hour*).

Voyager 2 is currently 7 billion kilometers (*4.35 billion miles*) from Earth, having traveled 10.28 billion kilometers (*6.38 billion miles*) since its launch in August 1977. The Voyager 2 spacecraft is departing the solar system at a speed of 16.08 kilometers per second (*35,970 miles per hour*).

Both Voyager spacecraft are healthy and continue their departure from the solar system. As they travel farther and farther from the Sun, the two spacecraft are returning data to characterize the outer solar system environment and search for the heliopause boundary, the outer limit of the Sun's magnetic field and outward flow of the solar wind.

Six science instruments on each Voyager spacecraft are collecting data on the strength and orientation of the Sun's magnetic field; the composition, direction and energy specta of the solar wind particles and interstellar cosmic rays; the strength of radio emissions that are thought to be originating at the heliopause, beyond which is interstellar space; and the distribution of hydrogen within the outer heliopause. These data are transmitted to Earth in real time, at 160 bits per second, and captured by 34-meter-diameter antennas of the Deep Space Network. Data are transmitted to JPL and made available in electronic files to the science teams located around the country for processing and analysis.

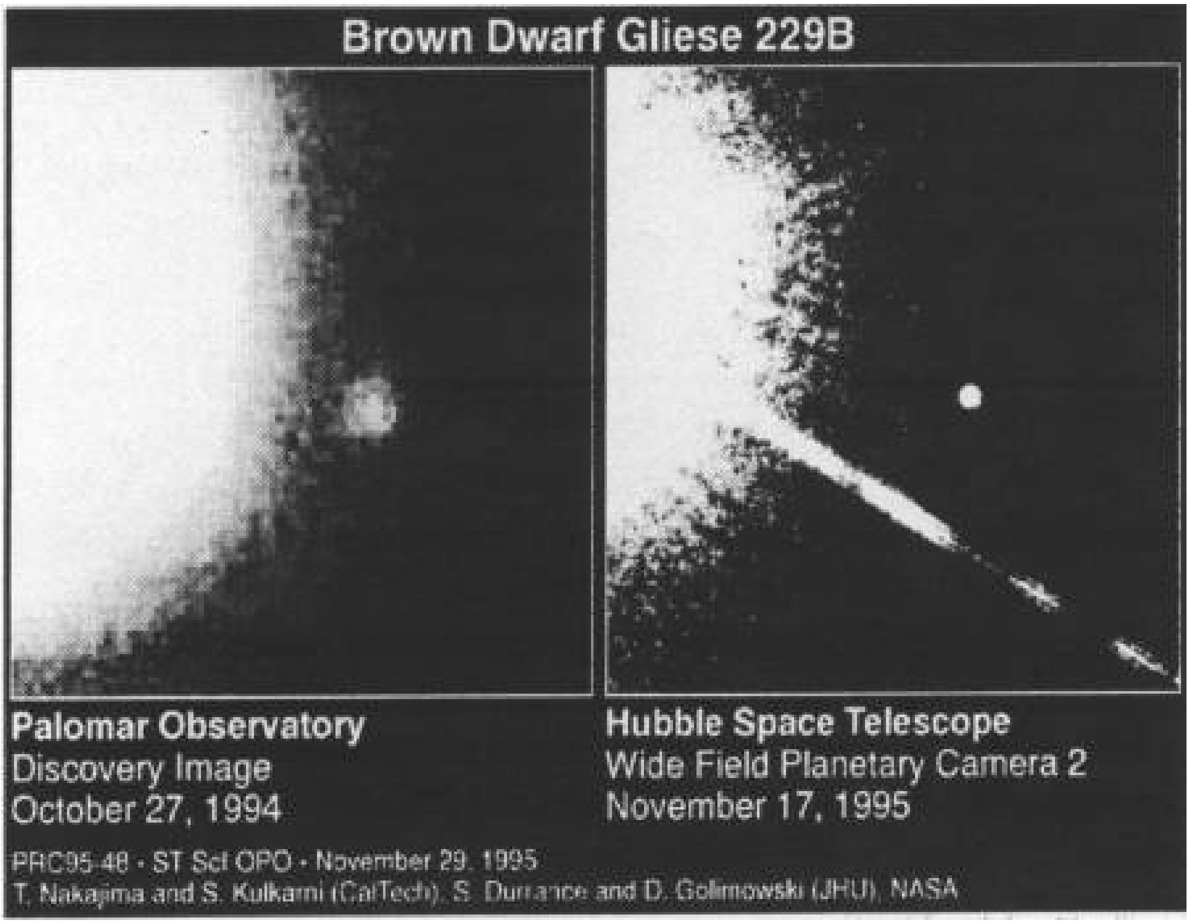
Flight controllers believe both spacecraft will continue to operate and send back valuable data until at least the year 2015. It is the loss of electrical power from their radioisotope thermoelectric generators (RTGs) that will eventually cause them to stop functioning. At launch, the three RTGs on each spacecraft had a power output of 475 watts. Today, that output is 341 watts for Voyager 1 and 345 watts for Voyager 2. Approximately 215 watts are necessary to operate the spacecraft and limited science instruments.

The other vital consumable onboard the spacecraft is the amount of hydrazine propellant which keeps the Voyagers stable and pointed toward Earth. Each spacecraft started out with 104 kilograms of propellant. Today, after 18 years of flight, including multiple planetary encounters and trajectory correction maneuvers, Voyager 1 has 34 kilograms of hydrazine remaining and Voyager 2 has 36 kilograms remaining. However, during the current, quiet phase of the mission, each spacecraft uses only about six grams of fuel a week. Flight controllers stress the Voyagers will run out of electrical power long before they start spinning out of control due to loss of their attitude-adjusting propellant.

It is estimated that Voyager 1 will pass the Pioneer 10 spacecraft in January 1998 to become the most distant human-made object in space.

ASTRONOMERS ANNOUNCE FIRST CLEAR EVIDENCE OF A BROWN DWARF

Astronomers have made the first unambiguous detection and image of an elusive type of object known as a brown dwarf. The evidence consists of an image from the 60-inch observatory on Mt. Palomar, a spectrum from the 200-inch Hale telescope on Mt. Palomar and a confirmatory image from NASA's Hubble Space Telescope. The collaborative effort involved astronomers at the California Institute of Technology, Pasadena, CA, and the Johns Hopkins University, Baltimore, MD.



Gliese 229B (*GL229B*), is a small companion to the cool red star Gliese 229, located 18 light-years from Earth in the constellation Lepus. Estimated to be 20 to 50 times the mass of Jupiter, GL229B is too massive and hot to be classified as a planet as we know it, but too small and cool to shine like a star. At least 250,000 times dimmer than Earth's Sun, the brown dwarf is the faintest object ever seen orbiting another star.

"*This is the first time we have ever observed an object beyond our Solar System which possesses a spectrum that is astonishingly just like that of a gas giant planet*," said **Shrinivas Kulkarni**, a member of the team from Caltech.

Kulkarni added, however, that "*it looks like Jupiter, but that's what you'd expect for a brown dwarf.*" The infrared spectroscopic observations of GL229B, made with the 200-inch Hale telescope at Palomar, show that the dwarf has the spectral 'fingerprint' of the planet Jupiter — an abundance of methane. Methane is not seen in ordinary stars, but it is present in Jupiter and other giant gaseous planets in our Solar System.

The Hubble data obtained and analyzed so far already show the object is far dimmer, cooler (*no more than 1,300 degrees Fahrenheit*) and less massive than previously reported brown dwarf candidates, which are all near the theoretical limit (*eight percent the mass of our Sun*) where a star has enough mass to sustain nuclear fusion.

Brown dwarfs are a mysterious class of long-sought objects that form the same way stars do, that is, by condensing out of a cloud of hydrogen gas. However, they do not accumulate enough mass to generate the high temperatures needed to sustain nuclear fusion at their core, which is the mechanism that makes stars shine. Instead, brown dwarfs shine in the same way that gas giant planets like Jupiter radiate energy, that is, through gravitational contraction. In fact, the chemical composition of GL229B's atmosphere looks remarkably like that of Jupiter.

The discovery is an important first step in the search for planetary systems beyond the Solar System because it will help astronomers distinguish between massive Jupiter-like planets and brown dwarfs orbiting around other stars. Advances in ground- and space-based astronomy are allowing astronomers to further probe the "twilight zone" between larger planets and small stars as they search for sub-stellar objects, and eventually, planetary systems.

Caltech astronomers Kulkarni, Tadashi Nakajima, Keith Matthews, and Ben Oppenheimer, and Johns Hopkins scientists Sam Durrance and David Golimowski first discovered the object in October 1994. Follow-up observations a year later were needed to confirm it is actually a companion to Gliese 229. The discovery was made with a 60-inch reflecting telescope at Palomar Observatory in southern California, using an image-sharpening device called the Adaptive Optics Chronograph, designed and built at the Johns Hopkins University.

The same scientists teamed up with Chris Burrows of the Space Telescope Science Institute to use Hubble's Wide Field Planetary Camera-2 for follow-up observations on November 17. Another Hubble observation six months from now will yield an exact distance to GL229B.

The astronomers suspect that the brown dwarf developed during the normal star-formation process as one of two members of a binary system. "*All our observations are consistent with brown dwarf theory,*" **Durrance** said. However, the astronomers say they cannot yet fully rule out the possibility that the object formed out of dust and gas in a circumstellar disk as a "super-planet."

Astronomers say the difference between planets and brown dwarfs is based on how they formed. Planets in the Solar System are believed to have formed out of a primeval disk of dust around the newborn Sun because all the planets' orbits are nearly circular and lie almost in the same plane. Brown dwarfs, like full-fledged stars, would have fragmented and gravitationally collapsed out of a large cloud of hydrogen but were not massive enough to sustain fusion reactions at their cores.

The orbit of GL229B could eventually provide clues to its origin. If the orbit is nearly circular, then it may have formed out of a dust disk, where viscous forces in the dense disk would keep objects at about the same distance from their parent star. If the dwarf formed as a binary companion, its orbit probably would be far more elliptical, as seen on most binary stars. The initial Hubble observations will begin providing valuable data for eventually calculating the brown dwarf's orbit. However, the orbital motion is so slow, it will take many decades of telescopic observations before a true orbit can be calculated.

Astronomers have been trying to detect brown dwarfs for three decades. Their lack of success is partly due to the fact that as brown dwarfs age they become cooler, fainter, and more difficult to see. An important strategy used by the researchers to search for brown dwarfs was to view stars no older than a billion years. Caltech's Nakajima reasoned that, although brown dwarfs of that age would be much fainter than any known star, they would still be bright enough to be spotted.

"*Another reason brown dwarfs were not detected years ago is that imaging technology really wasn't up to the task,*" **Golimowski** said. With the advent of sophisticated light sensors and adaptive optics, astronomers now have the powerful tools they need to resolve smaller and dimmer objects near stars.

Hubble was used to look for the presence of other companion objects as bright as the brown dwarf which might be as close to the star as one billion miles. No additional objects were found, though it doesn't rule out the possibility of Jupiter-sized or smaller planets around the star, said the researchers.

The results will also appear in the November 30 issue of the journal *Nature* and the December 1 issue of the journal *Science*.

The **Space Telescope Science Institute** is operated by the **Association of Universities for Research in Astronomy, Inc.** (*AURA*) for NASA, under contract with the **Goddard Space Flight Center**, Greenbelt, MD. The Hubble Space Telescope is a project of international cooperation between **NASA** and the **European Space Agency** (*ESA*).

GALILEO MISSION STATUS
December 7,1995
6:10 p.m.

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JET PROPULSION LABORATORY
CALIFORNIA INSTITUTE OF TECHNOLOGY
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
PASADENA, CALIF. 91109
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NASA's Galileo spacecraft has successfully entered orbit around Jupiter after its six-year trip through the solar system.

Project engineers report the spacecraft's rocket fired on time at 5:20 p.m. PST and stopped after 49 minutes as planned at 6:08 p.m. PST, enabling the spacecraft to enter orbit around the giant planet and begin its two-year mission of scientific studies.

Launched October 18,1989, Galileo has traveled 3.7 billion kilometers (*2.3 billion miles*) in a looping path through the solar system to reach Jupiter, which is 934 million kilometers (*580 million miles*) away from Earth.

GALILEO MISSION STATUS
December 10, 1995
4:20 a. m.

NASA's Galileo spacecraft, now in orbit around the planet Jupiter, this morning began the first scheduled return of data from its companion atmospheric probe that parachuted into the jovian atmosphere last Thursday.

Receipt of probe data from the spacecraft began at 4:15 a.m. PST and is scheduled to continue throughout the day.

This afternoon at the Jet Propulsion Laboratory in Pasadena CA, Galileo scientists will check this first batch of data to assess the quality of the information collected by the probe, said Galileo Project Scientist Dr. Torrence Johnson.

The probe data is the first-ever direct measurement of the giant planet's atmosphere and should reveal details of Jupiter's composition, climate and circulation. Forty minutes of data collected by the probe stored in the orbiter's onboard computer memory will be radioed to Earth over the next four days and presented to Galileo scientists for analysis. In early February, the full collection of probe data stored on Galileo's tape recorder, up to 75 minutes' worth, will be played back to receivers on Earth.

Preliminary analysis of the probe data will be presented at a press briefing December 19 at NASA's Ames Research Center, Mountain View, CA.

The Galileo orbiter's mission, meanwhile, is to conduct two years of detailed studies of Jupiter, its moons and the planet's magnetic environment. The project is managed by JPL.

GALILEO MISSION STATUS
December 15,1995

The Galileo spacecraft, now in orbit around Jupiter, finished delivering the first round of data from its atmospheric probe on Wednesday. Collected during the probe's one-hour plunge through Jupiter's clouds on Dec. 7, the data represent the first direct measurement of an atmosphere of an outer planet.

Galileo Project Scientist Dr. Torrence Johnson and Probe Scientist Dr. Rich Young confirmed that all the instruments seem to have worked properly and provided data during the probe's brief descent mission. The probe sent data to the Galileo orbiter for 57 minutes during its descent.

Transmission of probe data to Earth has now been temporarily suspended as planned, because Jupiter is passing behind the Sun as seen from Earth and the communications link between the Galileo orbiter and Earth has, as expected, become very noisy. The spacecraft is currently more than 940 million kilometers (*584 million miles*) from Earth. Data transmission will resume in January, when Jupiter and the Earth move out of this alignment.

Scientists are continuing to analyze the data in preparation for a briefing on the initial probe science results scheduled for 10 a.m. PST on Tuesday, Dec. 19, at NASA's Ames Research Center, Mountain View, CA.

SATURDAY, 12/2/95 MEETING NOTES
By: Tom Hanson

Dr. Dixon, Steve Brown, Jerry Ehman and Mark Sundstrom were in attendence.

Dr. Dixon had attended a computer conference in New Orleans, and he pronounced the city name like a native. He has spoken with a writer of children's books who is interested in **SETI**, and he had invited the writer to visit a Saturday meeting. Dr. Paul Shuck called. He is attempting to put together a 25th reunion of the *Cyclops* study (*less Barney Oliver*). Paul is continuing his efforts to build an inexpensive low noise amplifier. He is using transmitting transistors, because they are able to handle the large dynamic range characteristic of radio astronomy.

Mark Sunstrom has looked at data provided by Russ recently. He reported that the data does not show a problem such as Russ Childers had forecast as the declinations became lower. If Russ has taken steps to compensate, then they are working.

Mark visited Toronto recently, and found a copy of the 1996 *Guinness Book of Records* for sale. It turned out that the British issue of the book does not include **Big Ear**, or much of anything else which might be of interest to United States citizens.

Steve Brown is continuing his work to evaluate optical lense technology for FFT. The original *Cyclops* report identified limitations and Steve has independently confirmed them. Nevertheless, Steve has thought of a number of applications, and he is planning to write a paper on his research.

Jerry Ehman inquired about possible use of hologram technology in conjunction with optical FFT. Steve said he had not yet considered this idea, but found it interesting.

One of Steve's possible applications would be an extremely fast, coarse signal scan, to reduce search space by 10%.

At the close of the meeting, there was a brief discussion of what it might take to build a minimal **Argus** system. An atomic clock can be purchased for about $50K these days, but *GPS* might provide a suitable secondary standard for much less. Steve Brown estimated that each **Argus** node might be built for about $2,000 plus a suitable PC for data gathering.

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